Amendments to the Specification:

Please replace paragraph **[0044]** with the following amended paragraph:

[0044] In preferred embodiments, a mathematical form for relationship 40 is generated, and the above process of finding refractive index values from measured beam width values is done by evaluating the mathematical form. In other words, from the data, a mathematical relationship can be generated which gives the refractive index as a function of a variable, whose value is set ~~**equal**~~ to **equal** the measured beam width. The mathematical form can have many embodiments. For example, in **one** such embodiment, a quadratic equation having the form $RI=a*BW^2 + b*BW + c$, where RI is a variable representing **the** refractive index and BW is a variable representing measured beam width, can be fitted to the data using well known least-squares fitting methods. In a second such embodiment, the mathematical form may comprise a set of linear equations of the form $RI=b_i*BW + c_i$, with each linear equation connecting two data points and being used to provide the relationship between those two data points. In a third such embodiment, the mathematical form may comprise a mathematical spline function, many forms of which are well-known to the mathematics art. Other mathematical functional forms are possible, and the present invention is not limited to the examples provided above.

Please replace paragraph **[0046]** with the following amended paragraph:

[0046] A number of approaches may be used to position assembly 11 from beam profiler 30 to achieve the desired separation distance D_S. In one approach, distance D_0 of assembly is set substantially equal to D_S, and **the** assembly is abutted against the protective facing **[[for]]** **of** the optical capture window of profiler 30. To compensate for the small distance between the protective facing and **the** optical capture window of **the** profiler, the value of D_0 is to be less than D_S by this small distance. In preferred embodiments in this first approach, since light exiting lens 24 can reflect off substrate 12 and affect the measured beam profile, the top surface of substrate 12 in the area between lens 24 and side 14 is treated so as to be light-

absorbing, such as ~~being coated~~ **by coating it** with a light-absorbing material. In a second approach, assembly 11 is constructed with distance D_0 set to a value near zero, and assembly 11 is placed in a fixture 50, as shown in FIG. 9. Fixture 50 comprises a frame or substrate 51, a first retainer 52 disposed on frame/substrate 51 for holding substrate 11, a second retainer 56 disposed on frame/substrate 51 for attaching to the optical capture element of profiler 30 (or in some cases holding the optical capture element of profiler 30 depending upon the type of profiler used), and an optically-cleared area 54 disposed between retainer 52 and 56. Fixture 50 substantially sets (*i.e.*, substantially fixes) the distance between lens 24 and the optical capture window of profiler 30 to the desired value of D_S. As one exemplary embodiment, each of elements 52, 54, and 56 may comprise a respective recess in a substrate 51 (as shown in FIG. 9). In other embodiments, first and second retainers 52 and 56 may comprise holders (*e.g.*, clamps) that are attached to a common frame 51 and elevated above the body of the frame to provide optically-cleared area 54.

Please replace paragraph **[0049]** with the following amended paragraph:

[0049] To measure other ranges of refractive index, it is best to construct lens 20 and 24 to provide a relationship 40 with good slope characteristics (*i.e.*, not too shallow, and with a good divergence pattern as shown in FIG. 7). After selecting a desired RI measurement range for assembly 11, one of ordinary skill in the art, in view of the teaching of this disclosure, can employ commercially available optical simulation software well known to the art (such as OptiBPM® by Optiwave Corporation) to select the parameters of ~~the lens~~ **lenses** 20 and 24 and the length of gap 22 to provide for a relationship 40 with good characteristics for the desired range. As some basic guidance, we provide the following qualitative guidance. To measure a refractive index range that is greater than that targeted by Example 1, such as a range around 1.6 instead of 1.33, the transverse axis of one or both of the lenses 22 and 24 (T_S and/or T_C) should be reduced. To measure a refractive index range that is less than that targeted by Example 1, such as a range around 1.1 instead of 1.33, the transverse axis of one or both of the lenses 22 and 24 (T_S and/or T_C) should be increased.

Please replace paragraph **[0052]** with the following amended paragraph:

[0052] As to measuring temperature dependency, there are a number of possible configurations that may be used. FIG. 12 shows an implementation of assembly 11 that includes a heater element driven by a heater driver, and a temperature sensor which is coupled to a temperature sending unit. The heater element may comprise highly resistive material that is **[[feed]]** **<u>fed</u>** with power from the heater driver, and the heater driver **~~received~~** **<u>receives</u>** instructions from controller 60 (shown in FIG. 6). The heater element may be disposed on one or both of lenses 20 and 24, in close proximity to lens gap 22. There are several materials suitable for this purpose and that are well known to the art. The temperature sensor may comprise any of the well-known materials used for temperature sensors; these materials generally have large temperature coefficients (large charge in resistor for a change in temperature). The temperature sensor is coupled to a sending unit, which conveys a measured temperature value to controller 60. It is preferred in this embodiment that the temperature sensor be separately removable from assembly 11 so that it may be used for other assemblies. However, it is possible to integrate the temperature sensor on assembly 11, such as at the bottom of lens gap 22, or on top of one or both of lenses 20 and 24.

Please replace paragraph **[0056]** with the following amended paragraph:

[0056] A number of approaches may then be used to assemble a correlated list of measured refractive indices of substance 1 and applied electric field. For example, controller 60 may have one of its control outputs coupled to the voltage source to direct the selection of specific voltages applied to the electrodes, while it instructs beam profiler 30 to measure the beam width at selected voltages. In other examples, the voltage source may be configured to vary its voltage in a pattern, such as in a sinusoidal pattern or triangular-wave pattern, and **<u>the</u>** controller may be configured to have a sensing input coupled to the voltage source to receive its current voltage value (**~~or voltage~~** **<u>or a voltage</u>** sensor device may be used instead). In this

embodiment, controller 60 may instruct beam profiler 30 to measure the beam width when specific voltage levels are reached or when specific time points occur, or controller 60 may be configured to receive periodic beam width measurements from profiler 30, and correlate these measurements in time with the measured voltage values it receives. Although the control structure of each of the above embodiments is different, controller 60 is able to assemble a correlated list of measured beam widths and voltage levels, and from this a correlated list of refractive indices of substance 1 and electric field can be generated. From this, a relationship between refractive index and electric field can be constructed, which may be expressed by mathematical formulas and/or graphs.

Please replace paragraph **[0058]** with the following amended paragraph:

[0058] A number of approaches may then be used to assemble a correlated list of measured refractive index of substance 1 and applied magnetic field. For example, controller 60 may have one of its control outputs coupled to the current source to direct the selection of specific current to the coil winding (which generates corresponding specific magnetic fields), while it instructs beam profiler 30 to measure the beam width at selected voltages. In other examples, the current source may be configured to vary its current in a pattern, such as in a sinusoidal pattern or triangular-wave pattern, and **<u>the</u>** controller may be configured to have a sensing input coupled to the current source to receive its current value (**~~or current~~** **<u>or a current</u>** sensor or magnetic field sensor may be used instead). In this embodiment, controller 60 may instruct beam profiler 30 to measure the beam width when specific current levels are reached or when specific time points occur, or controller 60 may be configured to receive periodic beam width measurements from profiler 30, and correlate these measurements in time with the measured current values (or magnetic field strength values) it receives. Although the control structure of each of the above embodiments is different, controller 60 is able to assemble a correlated list of measured beam widths and current levels (or magnetic field strength values), and from this can generate a correlated list of refractive indices of substance

1 and magnetic field. Therefom, a relationship between refractive index and magnetic field can be constructed, which may be expressed by mathematical formulas and/or graphs.

Please replace paragraph **[0061]** with the following amended paragraph:

[0061] A second invention of the present application is directed to enabling the measurement of optical loss, electro-optical **<u>(EO)</u>** coefficient **[[(EO)]]**, thermo-optical (TO) coefficient, birefringence, in **~~additional~~** **<u>addition</u>** to refractive index. Knowledge of these properties **~~are useful~~** **<u>is useful</u>** for designing devices with **[[the]]** optimal numerical aperture, mode field diameter, beam profile, coupling efficiency, and other device properties.

Please replace paragraph **[0062]** with the following amended paragraph:

[0062] FIG. 17 shows a top view of a first embodiment of a second invention of the present application where the refractive index of a body of material may be measured. This embodiment is based on beam deflection due to differences in refractive index. The embodiment comprises an assembly 111 for holding a sample 1b whose refractive index is to be measured. Assembly 111 comprises substrate 112 having a top surface, a first side 113, and a second side 114. Disposed on **<u>the</u>** top surface of substrate 112 is a first planar lens 120 that has a first surface for receiving light from a waveguide 118 or other optical coupling adaptor, and a second surface opposite to the first surface. Waveguide 118 and lens 120 may have the same layer construction as waveguide 18 and lens 20 described above. The second surface of lens 120 is preferably convex. When waveguide 118 is used to couple light to lens 120 and is formed with the same layer structure as lens 120 as one continuous piece, the curvature of the first surface of lens 120 does not matter. Also disposed on the top surface of substrate 112 is a second planar lens 124 that is located opposite to first planar lens 120. Second planar lens 124 has a first surface facing the second surface of first planar lens 120 and a second surface opposite to its first surface. There is a gap 122 between the planar lenses 120 and 124 having a spacing distance L1 between the opposing surfaces of the lenses. Gap

122 is adapted to receive sample 1b, as described in greater detail below. Without sample 1b disposed in gap 122, light would propagate from first planar lens 120 to second planar lens 124 along an optical axis 115. The first surface of second planar lens 124 is preferably substantially flat and substantially perpendicular to optical axis 115. The second surface of second planar lens 124 is preferably convex. Lens 124 may have the same layer construction as lens 24 described above.

Please replace paragraph **[0066]** with the following amended paragraph:

[0066] For a given range of index of refraction to be measured, it is **[[will]]** **<u>well</u>** within the skill of the art to use optical simulation software to select the various dimensions and curvatures of the lenses in view of present disclosure. In addition, the change in the refractive index of sample **[[1d]]** **<u>1b</u>** as a function of temperature, electric field, and magnetic field may be determined by using the setups shown in FIGS. 12-15, and by configuring controller 60 to control the interaction of the components, as described above in detail.

Please replace paragraph **[0068]** with the following amended paragraph:

[0068] For a given range of index of refraction to be measured, it is **[[will]]** **<u>well</u>** within the skill of the art to use optical simulation software to select the various dimensions and curvatures of the lenses in view of present disclosure. In addition, the change in the refractive index of sample **[[1d]]** **<u>1b</u>** as a function of temperature, electric field, and magnetic field may be determined by using the setups shown in FIGS. 12-15, and by configuring controller 60 to control the interaction of the components, as described above in detail.

Please replace paragraph **[0069]** with the following amended paragraph:

[0069] In addition, the variation of the refractive index to the electric field (specifically the electro-optic coefficient) can be measured by forming electrodes on the top and bottom surfaces of sample 1b before placing the sample in assembly 111", and thereafter applying a

voltage to the electrodes while measuring the beam deflection. This is illustrated in schematic form in FIG. 20. As a modification of this approach, one or both of the electrodes may be formed in the shape of a triangle, and the sample may then be placed in assembly 111 shown in FIG. 17 with its edge parallel to the first surface of planar lens 124. This is shown schematically in FIG. 21, where the top depiction shows the case where no voltage is applied (and therefore no deflection), and where the bottom depiction shows the case where a voltage is applied. Similarly, the variation of the refractive index to temperature (specifically the thermo-optic coefficient) can be measured by **elevating the sample's** ~~applying elevated~~ temperature **by applying heat** to the sample while measuring the beam deflection.

Please replace paragraph **[0071]** with the following amended paragraph:

[0071] This invention can be extended to measure another important optical property, the loss factor of the medium. This is typically difficult to measure for small samples because it is difficult to focus a test light on small samples, the losses associated with the test setup can be larger than the losses of the sample. The invention addresses these issues by using the assembly of FIG. 17 to overcome the first problem area, and by using two or more instances of the lens configuration, but with different spacing distances between lenses to allow different lengths of the sample to be measured. A difference in absorption between the two lengths can then be measured to find the loss per unit length. An exemplary assembly 211 for this is shown in FIG. 22. Two instances of assembly 111 of FIG. 17 have been integrated onto the same substrate 112, each instance using the same reference numbers as assembly 111, except that a prime symbol (') has been added to the reference numbers of the bottom instance. The two instances are identical except for the spacing distance of the gap between **[[lens]]** **lenses**, and the lengths of lenses 124 and 124'. The bottom instance has a larger spacing distance, which we have noted **[[at]]** **as** L2 in the figure. The top instance has a smaller spacing distance, which we have noted as L1. Prior to placing the samples in the assembly, light is passed through each lens assembly, and the profiler determines the maximum intensity for each instance. These measurements will be used to normalize

subsequent measurements, thereby removing the intrinsic loss in each lens assembly. As the next step, samples 1b and 1b' of the same material, but of different lengths, are placed into respective gaps 122 and 122'. Light is directed through each sample, and the profiler determines the maximum intensity for each instance, with the samples present. These measured intensities are divided by the respective measurements made without samples present to normalize them. The normalized values are then divided to find the loss for the difference in length between the two samples.

Please replace paragraph **[0072]** with the following amended paragraph:

[0072] In addition to characterizing loss properties, the above assemblies can be **[[use]]** **<u>used</u>** to quantify birefringence effects using a similar methodology.

Please replace paragraph **[0073]** with the following amended paragraph:

[0073] Since the above embodiments are **~~substrate based~~** **<u>substrate-based</u>**, they may be manufactured with conventional semiconductor **~~processes~~** **<u>processing</u>** steps, and made with high precision and low cost compared to conventional optics approaches that use micro-manipulator stages to hold and align components. In addition, misalignment of the components is minimized. Moreover, each assembly can be reused.

Please replace paragraph **[0074]** with the following amended paragraph:

[0074] As a fourth invention of the present application, a lens structure is integrated on a substrate in close proximity to an optical device to monitor the properties of an optical material of the device during operation, such as over long periods of time. The lens structure has a gap between two lenses, with the gap being filled with the optical material of the device to be monitored. The lens structure **<u>can be</u>** from any of assemblies 11, 111, 111', and 111" (FIG. 6, FIGS. 17-19). An embodiment of the fourth invention is shown at 200 in FIG. 23,

where assembly 111' (FIG. 18) and light source 5 have been integrated on substrate 112 with an optical device 201, which may take any form and may be used for any purpose. The exemplary optical device 201 comprises a 1x2 optical switch having an input waveguide 202 that conveys light to a collimating lens 204. The collimated light is provided as an input to an optic deflector 206, which comprises a body of electro-optic material 1b' and a triangular shaped electrode 208. Deflector 206 is commonly known as a prism deflector, and the electrode is commonly known as a prism electrode. **~~An voltage~~** **A voltage** applied to electrode 208 causes the refractive index of material 1b' to change with respect to the material that is not covered by electrode 208. This causes a difference in refractive index, which in turn **[[cases]]** **causes** the beam to deflect in relation to the applied voltage because the triangle cuts across the **[[beam]]** **beam's** axis. A ground electrode may be formed below the body of material 1b', or the substrate 112 may be used as a ground electrode.

Please replace paragraph **[0075]** with the following amended paragraph:

[0075] A positive voltage deflects the beam in one direction, while a negative voltage deflects the beam in the opposite direction. Two directions thus arise, allowing the input signal to be diverted to one of two outputs to provide the 1x2 switch. Deflector 206 is abutted against a slab waveguide 210 to couple its output thereto. Slab waveguide 210 enables the two possible **~~defected~~** **deflected** beam paths to develop some spatial separation so **[[the]]** **they** may be collected by respective focusing lenses 212 and 214. The focusing lenses feed respective output waveguides. Slab waveguide 210 has a curved exit surface to assist in **[[the]]** focusing.

Please replace paragraph **[0076]** with the following amended paragraph:

[0076] A controller 220 receives an input switch signal which indicates the **~~desire~~** **desired** optical coupling of the input signal to one of the two output **~~signal~~** **signals**. Conventionally, controller 220 would be initially calibrated to apply the required voltages to effect the

couplings. These voltages would remain in place until the end-of-use of the device. A problem arises, however, in that the optical properties of material 1b change with time, which can cause degradation in the optical coupling of the signal to the outputs. In the fourth invention, a representative sample 1b of the electro-optic material is monitored by an embodiment of assembly 111", light source 5, and beam deflection profiler 130. Beam profiler 130 may comprise an array of closely spaced photo-detectors to sense the position of the deflected beam, and circuitry that provides controller 220 with an indication of the deflection or an indication of the refractive index. Using this information, controller 220 may comprise a pre-stored relationship (such as in the form of a table or mathematical equation) of the applied voltages to use for deflector 206 based on the measured ~~**result**~~ **results** provided by source 3, assembly 111", and profiler 130. The relationship may indicate the absolute voltage values to use, or may indicate delta voltage corrections from base voltage values. As a further feature, an electrode may be formed on the top surface of sample 1b, and the controller may apply various voltages to sample 1b as part of the monitoring process.

Please replace paragraph **[0078]** with the following amended paragraph:

[0078] It may be appreciated that the fourth embodiment may also be ~~**practice**~~ **practiced** using apparatus 10 shown in FIG. 6. In this case, the electro-optic material 1b' for the optical device and for substance 1 may be formed from a liquid and subsequently cured to a solid state. The beam profiler 30 may also comprise an array of photo-detectors and internal analog circuitry and digital circuitry that determines the beam width from the relative intensities on the photo-detectors. For this, the input of a single analog-to-digital conversion circuit may be ~~**multiplex**~~ **multiplexed** between the outputs of the photo-detectors to find the relative spatial intensity of the beam, and the digital circuitry may compare the detector outputs against the center detector's output to estimate the beam width.

Please replace paragraph **[0079]** with the following amended paragraph:

[0079] While the present invention has been particularly described with respect to the illustrated embodiments, it will be appreciated that various alterations, modifications and adaptations may be made based on the present disclosure, and are intended to be within the scope of the present invention. While the invention has been described in connection with what **[[is]]** **<u>are</u>** presently considered to be the most practical and preferred embodiments, it is to be understood that the present invention is not limited to the disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.